REMARKS

This amendment is responsive to the Final Office Action of March 18, 2008. Reconsideration and allowance of the claims 2-14 are requested.

The Office Action

Claim 10 and claims 2-5, 7, ,11, and 12 dependent therefrom stand rejected under 35 U.S.C. § 103 as being unpatentable over Vollmar ("Iterative Reconstruction of Emission Tomography Data...") in view of Townsend (US 6,490,476), further in view of Delaney ("Multi-Resolution Tomographic Reconstruction Using Wavelets").

Claim 6 stands rejected under 35 U.S.C. § 103 as being unpatentable over Vollmar in view of Delaney.

Claims 13-14, which depend from claim 6, stand rejected under 35 U.S.C. § 102 as being anticipated by Vollmar taken alone or, possibly, in combination with Schmidlin ("Iterative Reconstruction of PET Images...").

Claim 8 stands rejected under 35 U.S.C. § 103 as being unpatentable over Vollmar in view of Delaney.

Claim 9 stands rejected under 35 U.S.C. § 102 as being anticipated by Vollmar taken alone or, possibly, in combination with Schmidlin.

The Office Action is Inconsistent

The Office Action purports to reject claim 6 under 35 U.S.C. § 103 as being obvious over Vollmar in view of Delaney, while rejecting claims 13-14, which depend from claim 6, under 35 U.S.C. § 102 as being anticipated by Vollmar. It is axiomatic, that a dependent claim includes all of the subject matter of its parent claim. Accordingly, if a single reference does not anticipate the parent claim, it is submitted that a single reference cannot anticipate its dependent claims. Conversely, because dependent claims further limit their parent claim, it is submitted that if dependent claims 13-14 are anticipated by a single reference, then parent claim 6 must also be anticipated by that same single reference.

The Present Amendment Should Be Entered

First, the present amendment amends claim 9 as the Examiner suggested. Because this amendment merely resolves a potential indefiniteness due to a wording inconsistency, it is submitted that it should be entered as reducing the issues on appeal.

Second, claim 7 has been amended to correct a potential antecedent basis issue. Specifically, claim 7, line 3, refers to "the computer program". Antecedent basis to "the computer program" is found in "programming" recited in line 2. The applicant has proposed amending line 2 to resolve this wording inconsistency and to resolve this previously unrecognized antecedent basis issue.

The Rejection of Claims 9, 13, & 14 as Being Anticipated By a Combination of Two References is Improper

The Examiner's assertion that the Vollmar article "includes" the Schmidlin article is not correct. Rather, the Vollmar article references the Schmidlin article as a source for explaining the details of the high over-relaxation single projection (HOSP) reconstruction algorithm. The Schmidlin article is not incorporated in the Vollmar article. Rather, because it is a separate and independent reference which, as the Examiner properly noted, is necessary to the rejection, then the rejection should properly be made under 35 U.S.C. § 103.

It is further noted that Schmidlin explains his HOSP reconstruction algorithm as an improvement over the maximum likelihood (ML-EM) algorithm of Shepp and Vardi which, also must be understood in order to understand Schmidlin. Accordingly, it is submitted that the Examiner should also make the Shepp and Vardi article referenced in Schmidlin of record and a part of the combination. For the reasons set forth below, the Office Action evidences a lack of understanding of the ML-EM algorithm, which manifests itself in a misunderstanding of the HOSP algorithm, which , in turn, results in inappropriate combinations of references which do not disclose that which the Examiner asserts they do, or when combined, in a combination which performs as the Examiner asserts.

Conversely, the Examiner fails to make the Lipinski article of record that Vollmar references. Without the Lipinski article, the modification of Lipinski's

assumption (1) at page 1560, column 2, lines 2-5, renders Vollmar incomplete and non-enabling.

The References of Record

Vollmar uses an iterative reconstruction technique, particularly the HOSP technique, which iteratively adjusts a reconstructed image based on unreconstructed image data from both a PET source and an MR source. The applicant again references the sections of the present application referenced in Amendment B, which discuss the Vollmar reference and its deficiencies which are overcome by the present application. As pointed out at the top of the first column of page 1561 in the first paragraph under "D. Problems", one cannot weight the MR data too heavily in the HOSP image reconstruction or else it would suppress the lower-resolution PET data. To prevent the MR data from dominating too strongly, Vollmar weights the MR data with a Markov parameter β which, as shown in Figure 4(c)-(e), can range from 0.0005 to 0.0050.

More specifically, going down the PET study line of Vollmar, Vollmar corrects the PET study data for attenuation correction as well as normalization, scatter correction, and arc-correction. The corrected PET data, typically LORs (lines of response) are backprojected to reconstruct an image. The image is forward projected to form sinograms (please google "sinogram" as it is important to understand or see www.medcyclopaedia.com/library/topics/volume_i/s/sinogram.aspx or www.en.wikipedia.org/wiki/sinogram). Sinograms are different from the original LORs. Sinograms are partial processed (Radon transformed) data which has a sinusoid or spiral trajectory.

The data from the MR study is reconstructed into an image which is registered to the PET image. The MR image is segmented to generate *a-priori* information for the segmented region.

The sinograms are then reconstructed using the iterative HOSP improvement on the ML-EM algorithm.

ML-EM Reconstruction

The applicant again requests that the Examiner refer to the Shepp and Vardi article referenced in Schmidlin for a complete and accurate explanation of the ML-EM algorithm. However, in the absence of the cited reference providing these details, a short overview of this type of iterative reconstruction technique is presented herein.

In a conventional CT reconstruction, the data represents a forward projection of the radiation attenuation properties of the subject along the lines between the x-ray source and the individual detectors. Typically, a line of detectors are sampled concurrently to generate a line of CT data. Each line of CT data is then backprojected into image space to generate an appropriate image.

By contrast, in the estimated techniques, one starts with an initial estimated image, which is often a blank image. This image is mathematically forward projected along the direction of each CT projection line to generate a synthesized line of forward projected data corresponding to each actually collected line of CT data. The synthesized line of data is compared with the actually collected line of data to generate a correction line of data. In the ML-EM technique, this correction is based on maximum likelihood. This correction line of data is then projected into image space. This generation of a synthesized line of data and its comparison with an actual line of data is performed for each line of actually-generated CT data which results in an updated estimated image. This results in a rough estimated image which is starting to approximate the final image, but is still very coarse and incomplete. This forward project, compare, and backproject process is iteratively repeated until the estimated image converges on a final image. It will be noted that in each iteration, the correction will become smaller. This process is iteratively repeated, for example 80 times, according to Schmidlin, in order for image space to converge on a precise image.

Schmidlin proposes a technique, HOSP, for generating the correction data lines which converges more quickly, according to Schmidlin, in fewer than 10 iterations.

Vollmar's HOSP Reconstruction

Vollmar uses Lipinski's modified HOSP technique that uses *a-priori* information when determining the corrections (page 1560, column 1, "B. Algorithm" section, lines 1-3).

Vollmar modifies Lipinski's assumption (a) with a constraint that the pixels in the segment region of the MR image the same values (page 1560, column 2, lines 2-5).

Vollmark adjusts the influence of this same value segmented by using a Markov parameter β to weight the effect of assumption (a) which is related to the correctison to the sinogram data that is iteratively reconstructed into the region of the final PET image corresponding to the segmented portion of the MR image.

Schmidlin, at page 569, in the first paragraph, notes that the ML-EM algorithm requires more than 80 steps or iterations. Schmidlin proposes a modification to the ML-EM algorithm which converges on a high precision solution with less than 10 iterative steps. Note the paragraph which extends from the bottom of page 569 to the top of page 570.

Delaney is directed to an image reconstruction technique which is different from and inconsistent with the ML-EM or HOSP reconstruction algorithms. Delaney takes data from a single image data set, separates into a 2-D version of a wavelet representation, and then uses the wavelet representation to reconstruct an image in which the resolution is higher in some areas of the reconstructed image than others (page 799, column 1, second paragraph). More specifically, as illustrated in Figures 6 and 7, the image reconstruction is accelerated by generating an image which has relatively high resolution in a center black, lower resolution in a ring around the center, and the lowest resolution in an outer ring. It is submitted that if one were to combine Delaney with Vollmar, one might use the Delaney technique to reconstruct the initial MR data into the MR image which is manually segmented. However, the Delaney technique cannot be substituted for the HOSP algorithm because there is no explanation in Delaney as to how one would combine the wavelet reconstruction technique in order to accommodate data from multiple sources. There is no enabling disclosure regarding how to redesign the Delaney wavelet reconstruction to modify the reconstruction of one image data set based on a different segmented image.

Townsend, column 17, lines 23-41 referenced by the Examiner is directed to attenuation correction, as might be utilized in the second box of the PET column of Vollmar. As is well-known in PET imaging, the PET radiation is attenuated as it passes from the annihilation event within the patient through a portion of the patient to the detector. More specifically, the PET radiation is attenuated most heavily by dense structures such as bone. This results in a lower number of the gamma rays from annihilation events which pass through bone to reach a detector, because the dense bone absorbs more gamma rays than soft tissue. In order to correct for this non-uniform attenuation of the gamma rays, PET imaging typically uses an attenuation correction. In Townsend, the attenuation correction factor is determined by forward projecting a ray through the CT image along the same trajectory as the PET image LOR which is to be attenuation corrected. Once the PET gamma rays/LORs have been attenuation corrected with attenuation factors derived from a CT image, then the attenuation corrected LORs are reconstructed, such as by backprojection (again see the second block of Vollmar, Fig. 3 under "PET Study") to generate an initial PET image. Thus, the Townsend attenuation correction technique, if used with Vollmar, would be performed several steps prior to the HOSP reconstruction.

Independent Claim 10 and Dependent Claims 2-5, 7, 11, and 12 Distinguish Patentably Over the References of Record

First, **claim 10** calls for associating the segmented data set with the first image data set to form a segmented first image data set. Vollmar does not associate the segmented MR image with the PET sinogram data set. Rather, Vollmar forward projects the current estimated image to generate synthesized projection data which is compared with the PET corrected sinograms to generate corrections, which corrections are backprojected into the estimated image to generate the next iteration or generation of estimated images. In determining the correction, Vollmar does two things. First, Vollmar constrains assumption (a) of the cited Lipinski article with a constraint that assumes that all pixels within the segmented region have a common value (Vollmar, page 1560, column 2, lines 1-5). Vollmar weights this assumption with the Markov parameter β to reduce the influence of the MR data. Thus, Vollmar does not operate on the PET image data with the segmented MR image data. Second,

Vollmar does not segment the sinogram data set to form a segmented data set and then reconstruct that segmented data set.

Claim 10 calls for forward projecting the segmented second image to form a segmented second image data set. By contrast, in Figure 3 of Vollmar, the oval box labeled "*a-priori* information appropriate anatomical regions" is a segmented image. It is not forward projected to synthesize a segmented second image data set. Rather, this box represents the segmented image. The segmented image is used to define the regions which are used to adjust assumption (a) of Lipinski, which is cited as Reference 2 in Vollmar. This adjustment of the constraints is based on regions of the segmented image and not based on a forward projected segmented second image data set.

Townsend does not cure the shortcomings of Vollmar. Townsend, at column 17, lines 23-41 referenced by the Examiner, merely indicates that the raw PET data should be attenuation-corrected in accordance with a CT image. Such attenuation is performed in Figure 3 of Vollmar in the box labeled "normalization, attenuation-, scatter-, arc-correction". These steps are performed well before the HOSP image reconstruction step and well before there is any influence from the MR study. As an aside, it should be noted that a CT image is an image representing attenuation and is suitable for use in attenuation correction. An MR image does not represent x-ray attenuation, but rather represents resonating dipoles, particularly proton or hydrogen dipoles. Accordingly, one would not typically try to use the MR image data of Vollmar in order to perform the attenuation correction. Rather, as stated in Townsend, one would use CT image data.

Delaney does not cure these shortcomings of Vollmar and Townsend. Delaney describes a wavelet image reconstruction technique. First, it is submitted that it would not be obvious to substitute the Vollmar wavelet reconstruction technique for the HOSP iterative reconstruction technique of Vollmar. Second, there is no enabling disclosure between Vollmar and Delaney as to how one could substitute the wavelet reconstruction technique for the HOSP iterative reconstruction technique of Vollmar. Delaney describes a wavelet technique which would reconstruct the center portion of the image to a higher resolution than peripheral portions. It is not an iterative technique and there would be no generation of

correction data. Most specifically, there is no enabling explanation in Delaney or Vollmar how one could apply the modified assumption (a) of Lipinski to the wavelet reconstruction technique or to what and how would the Markov parameter β be applied. It is submitted that if one were told that they must incorporate the wavelet reconstruction technique of Delaney into the Vollmar technique, one would use the Delaney wavelet reconstruction technique to reconstruct the MR study using "any reconstruction method" as is recited in Figure 3 of Vollmar between the box labeled "MR study" and the box labeled "registration (MR to PET orientation)". This would then result in a higher resolution in the center of the image which, if the image were set up such that the portion of the image to be segmented is in the center, could prove advantageous. However, even if the segmented MR image has lower resolution around the edges, using such an MR segmented image would not meet the limitations of claim 10. There is still no forward projection of such segmented image nor is there any associated of the segmented image data with first sinogram data to form a segmented first image data set.

In summary, neither Vollmar, nor Townsend, nor Delaney, individually or in combination, suggest that one should forward project the segmented MR image of Vollmar. Indeed, Vollmar derives *a-priori* information as to the segmented region from the segmented image and does not forward project the segmented MR image. None of these references, nor their combination, suggest forming a segmented PET image data set based on a segmented MR image data set and reconstructing the segmented first image data set. Rather, Vollmar (the only one of the three references which suggest influencing a PET image with an MR image) states that the influence of the segmented MR image should be applied during the iterative reconstruction of the PET image data set into a PET image without first segmenting the PET image data set.

Accordingly, it is submitted that **claim 10 and claims 2-5, 7, 11 and 12 dependent therefrom** distinguish patentably and unobviously over the references of record.

Claim 3 calls for the segmentation to be performed by an automatic segmenting step. By contrast, in Figure 3 of Vollmar, the segmentation is specifically

called for as being performed "manually" (note the "segmentation" descriptor mid-way down the MR column of Figure 3).

Claim 6 is Patentable Over Vollmar and Delaney

Claim 6 calls for a selection means which selects a portion of the first image data set such that the reconstructed image is calculated exclusively from the portion of the first image data set which is situation in a selected region of a second image data set. Vollmar generates an improved resolution PET image using an iterative reconstruction technique in which assumption (a) of Lipinski has been modified in accordance with a segmented MRI image. The Delaney image reconstruction technique is a wavelet technique, not an iterative technique. There is no enabling disclosure in Delaney or Vollmar as to how one would incorporate the iterative backprojection assumption (a) of Lipinski into the non-iterative reconstruction technique of Delaney.

Moreover, conversely, although the wavelet reconstruction technique can be utilized to generate images that have a higher resolution in a center rectangle and lower resolution around the periphery, there is no enabling disclosure in Delaney or Vollmar as to how one would achieve such differential resolution in other than the wavelet reconstruction technique of Delaney. More specifically, there is no enabling disclosure as to how one would motify the iterative HOSP reconstruction technique in order to generate a PET image which is high resolution in the center and lower resolution around the edge.

Finally, claim 6 does not call for generating a final image which has a higher resolution in the center and a lower resolution around the edge.

Accordingly, it is submitted that **claim 6 and claims 13-14 dependent therefrom** are patentable in the sense of 35 U.S.C. § 103 over Vollmar and Delaney.

Claims 13 and 14, which depend from claim 6 are not anticipated by Vollmar in combination with Schmidlin.

Claims 13 and 14, which Depend from Claim 6, Are Not Anticipated by Vollmar in Combination With Schmidlin

As set forth above and in the Office Action, Vollmar does not disclose the limitations of claim 6. Deleting Delaney and adding Schmidlin to the combination

does not cure the shortcomings of Vollmar. Schmidlin merely explains how to implement the HOSP algorithm in order that the iterative reconstruction technique converges more quickly on a high resolution image. There is no suggestion in either Vollmar, nor Schmidlin, nor the combination, how one could generate a final PET image from the portion of the PET image data which is situated in the segmented region of the MR image.

Claim 8 is Patentable Over the Combination of Vollmar and Delaney

Claim 8 calls for generating a segmented first image data set and then reconstructing the weighted first image data set into an image. By contrast, Vollmar reconstructs sinogram image data, into an image using an HOSP iterative reconstruction algorithm. In order to influence the PET image with a segmented region of an MRI image, Vollmar replaces assumption (a) of Lipinski relating to the correction determination in an iterative reconstruction with a less strict constraint that the pixels within a region extracted from the *a-priori* data tend to have the same values and applies the Markov parameter β. Vollmar does not generate a segmented first image data set.

Delaney does not cure this shortcoming of Vollmar. Delaney discloses a wavelet based image reconstruction algorithm. There is no suggestion in Delaney of generating a segmented first image data set which should be constructed using a wavelet representation. Moreover, there is no enabling disclosure how one might incorporate the wavelet image reconstruction of Delaney into the HOSP iterative reconstruction of Vollmar. If one were to replace the HOSP iterative reconstruction of Vollmar with the wavelet reconstruction of Delaney, then there would be no enabling disclosure as to how one would weight or alter the wavelet reconstruction in accordance with the segmented MR image. Assumption (a) of Lipinski and the Markov parameter β relate to deriving the corrections for an iterative reconstruction technique, and it is not apparent how it would be inapplicable to the non-iterative wavelet reconstruction technique.

Conversely, if one were to modify the HOSP iterative technique such that it is higher resolution in the center and lower resolution at the edges, such a combination would not meet the claim 8 requirement for segmenting the first image

data set to define a segmented first image data set and subsequently reconstructing an image from the segmented first image data set. Further, there is no enabling disclosure in Delaney or Vollmar as to how one would modify the HOSP iterative reconstruction technique in order to achieve higher resolution in the center of the image and lower resolution at the edges.

Accordingly, it is submitted that **claim 8** is not anticipated by the combination of Vollmar and Delaney.

Claim 9 is Patentable Over the Combination of Vollmar and Schmidlin

Claim 9 calls for calculating the image reconstruction from image data in a region represented by the first image data set that corresponds to the selected region represented in the second image data set. By contrast, Vollmar modifies assumption (a) of Lipinski with the constraint that the pixels within the region extracted from the MR data set by segmentation tend to have the same values and then applies a higher Markov parameter β based on the segmentation in order to preferentially weight the portions of the PET image data corresponding to the segmentation more heavily.

Schmidlin fails to cure these shortcomings of Vollmar. Schmidlin explains the details of the HOSP algorithm which selects the determined corrections such that the estimated image converges to the final image in less than 10 iterations.

Thus, Vollmar as modified by Schmidlin changes the constraints of assumption (a) of Lipinski in the segmented region and selects a Markov parameter β to determine the influence based on the segmented area and does not describe calculating a reconstructed image from a region of the PET image data that corresponds to the segmented region of the MR image. Accordingly, it is submitted that **claim 9** is not anticipated by the combination of Vollmar and Schmidlin.

35 U.S.C. § 112, First Paragraph

Claim 7 complies with the 35 U.S.C. § 112, first paragraph, written description requirement. Figures 1, 2, and 3 are each effectively a programmer's flowchart which set forth the operations to be performed, the order in which they are to be performed, and how the operations interact. From these flowcharts, it is a mere

matter of routine skill for a programmer of ordinary skill in the art to write software in the language of choice which implements the described functions.

Page 5, lines 1-3 of the present application indicate that a computer program is generated, which computer program is executed on a computer. It is axiomatic that the computer program must reside on a tangible medium, such as a computer memory, a disk or tape, a memory stick, or the like.

Accordingly, it is submitted that the present disclosure does provide a sufficient written disclosure of the subject matter of claim 7.

CONCLUSION

For the reasons set forth above, it is submitted that claims 2-14 distinguish patentably and unobviously over the references of record. An early allowance of all claims is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, she is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

FAY SHARPE LLP

Thomas E. Kocovsky, Jr.
Reg. No. 28,383
1100 Superior Avenue, 7th Floor
Cleveland, OH 44114-2579
(216) 861-5582